

(19) World Intellectual Property Organization
International Bureau



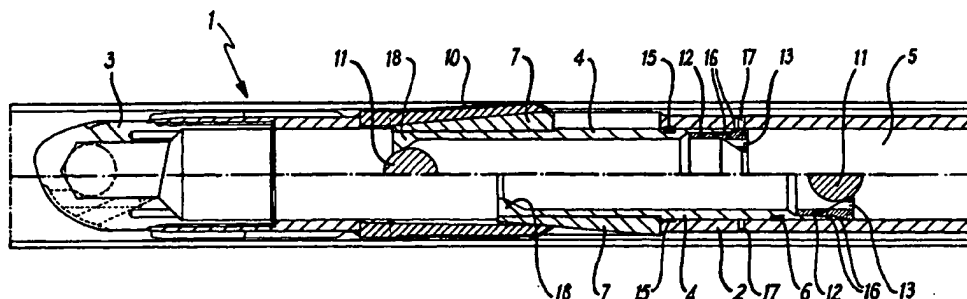
(43) International Publication Date
8 November 2001 (08.11.2001)

PCT

(10) International Publication Number
WO 01/83932 A1

- (51) International Patent Classification⁷: **E21B 7/20**, 17/14, 43/10
- (21) International Application Number: **PCT/GB01/01512**
- (22) International Filing Date: **2 April 2001 (02.04.2001)**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:
0010378.8 28 April 2000 (28.04.2000) **GB**
- (71) Applicants (*for all designated States except US*): **BBL DOWNHOLE TOOLS LIMITED** [GB/GB]; Suite 12, McNeill Business Centre, Greenbank Crescent, East Tullos, Aberdeen AB12 3BG (GB). **BAIN, James** [GB/GB]; 20 West Park Crescent, Inverbervie, Montrose DD10 0TX (GB). **HAITES, Binnert, Ruerd** [CA/GB]; 32 Cairn Road, Bieldside, Aberdeen AB15 9AL (GB).
- (72) Inventor; and
- (75) Inventor/Applicant (*for US only*): **TULLOCH, Rory, McCrae** [GB/GB]; 20 Ashley Park North, Aberdeen AB10 6SF (GB).
- (74) Agent: **KENNEDYS PATENT AGENCY LIMITED**; Floor 5, Queens House, 29 St Vincent Place, Glasgow G1 2DT (GB).
- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
- Published:**
— with international search report
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: **EXPANDABLE APPARATUS FOR DRIFT AND REAMING A BOREHOLE**



(57) Abstract: An expandable reamer shoe is provided for use with expandable casing in a borehole. The reamer shoe has a number of reaming members in the form of blades which remain closed against the body of the shoe when inserted through casing, and can then be expanded to underream below the casing. Additionally, the expandable reamer shoe is made substantially of a drillable material so that the borehole can be extended beyond the point reached by the expandable reamer shoe.

WO 01/83932 A1

1 Expandable Apparatus for Drift and Reaming a Borehole

2

3 This invention relates to an expandable reamer shoe which
4 can be used to drift and ream drilled well bores, as are
5 typically used in oil and gas production.

6

7 When constructing a well bore, it is standard practice to
8 drill in intervals. Firstly, a large surface hole is
9 created into which casing is installed to act as a lining
10 in the bore. Cement can then be displaced between the
11 external surface of the casing and the interior of the
12 well bore in order to structurally support the casing.
13 In order to drill the next and deeper section of the bore
14 it is common practice to use a smaller drill bit attached
15 to a drill string which can be lowered through the
16 previously installed casing in the first section of the
17 bore. Consequently, the next section of the bore, and
18 the casing installed within it, has a smaller diameter to
19 that which is above it. Further sections of well are
20 then lined with a length of even smaller casing which
21 runs back to the surface and is inserted into the bore by
22 the above described method. Several sections of hole may
23 be drilled before the final back to surface section, near

1 the production zone, is drilled and lined with liner,
2 which is hung inside the bore on the last string of
3 casing, rather than being run back to the surface like
4 the casing sections above it.

5
6 There have been a number of methods recently described
7 whereby steel casing (US Patent No 5667011 and WO
8 93/25799) can be expanded after it has been run into a
9 bore. Expandable casing overcomes the problem inherent
10 to conventional casing whereby as a consequence of the
11 normal installation procedure, the diameter of the
12 sections of casing decreases with depth in the well-bore.
13 However, if the well bore is not at the planned diameter
14 when the casing is expanded in the hole which may occur
15 for example, due to hole contraction after the drilling
16 run, there is a danger that the next string of casing
17 when expanded, will not go out to the full size, due to
18 the restricted hole diameter outside the casing.

19
20 When requiring to drill a hole below the casing, of a
21 size larger than the bore of the casing, it is standard
22 practice to use a drill string with an underreamer and
23 pilot bit. Underreamers are comprised of a plurality of
24 expandable arms which can move between a closed position
25 and an open position. The underreamer can be passed
26 through the casing, behind the pilot bit when the
27 underreamer is closed. After passing through the casing
28 the underreamer can be opened in order to enlarge the
29 hole below the casing. It is not feasible when running
30 expanded casing, to drill down the casing using an
31 underreamer attached, as underreamers are not drillable,
32 that is they can only be used when there is a certainty
33 that further sections of the bore will not be drilled, as

1 the subsequent drill bit or casing drill shoe would have
2 to pass through the underreamer in order to advance.
3 This is extremely difficult as underreamers are required
4 to ream and remove hard rock material and typically
5 comprise hard, resilient materials such as Tungsten
6 Carbide or steel. Drilling through an in-place
7 underreamer may result in damaging the drill bit or the
8 casing drill shoe, adversely affecting the efficiency of
9 any further drilling.

10

11 Other methods include the use of an expandable bit,
12 rather than an underreamer with a pilot solid crown bit,
13 and also a bi-centre bit.

14

15 It is therefore recognised in the present invention that
16 it would be advantageous to provide a reamer shoe which
17 can be used in conjunction with expandable casing and
18 which is itself expandable, and can drift and ream a
19 drilled section prior to expansion of the casing.

20

21 It is an object of the present invention to provide an
22 expandable reamer shoe which can be attached to casing
23 and which can drift and/or ream a previously drilled hole
24 regardless of whether the casing is being advanced by
25 rotation and/or reciprocation of the reamer shoe.

26

27 It is further object of the present invention to provide
28 an expandable reamer shoe which can be used with either
29 expandable casing or standard casing when desired.

30

31 It is a yet further object of the present invention to
32 provide an expandable reamer which is constructed from a
33 material which allows a casing drill shoe or drill bit to

1 drill through it such that the drill shoe or drill bit is
2 not damaged and can progress beyond the point reached by
3 the expandable reamer shoe within the well bore.

4
5 According to a first aspect of the present invention
6 there is provided a reamer shoe for mounting on a casing
7 string, the reamer shoe having a plurality of reaming
8 members wherein said reamer shoe is constructed from a
9 relatively soft drillable material, wherein the plurality
10 of reaming members are moveable between a first and
11 second position, and wherein the reaming members are
12 closed in the first position and expanded in the second
13 position.

14
15 Optionally the expandable reamer shoe can act as a drift.

16
17 Preferably the plurality of reaming members are in the
18 form of blades.

19
20 Optionally each of the blades has a hard facing applied
21 to the outer surface.

22
23 In one embodiment, the reaming members move from the
24 first closed position to the second expanded position by
25 virtue of the movement of an activating piston.

26
27 Most preferably said activating piston defines an
28 internal bore.

29
30 Preferably movement of the activating piston is provided
31 by an increase in hydrostatic pressure.

32

1 Preferably the increase in hydrostatic pressure is
2 provided by an obstructing means within the internal bore
3 of the activating piston.

4
5 Most preferably said obstructing means is a deformable
6 ball or dart.

7
8 Preferably the reaming members are fully expanded when
9 the ball communicates with a seat formation in the
10 internal bore.

11
12 Preferably the ball is held inside the bore of the
13 activating piston by a retainer ring.

14
15 Preferably the retainer ring has a plurality of by-pass
16 ports which allow fluid and mud to pass through the
17 retainer ring.

18
19 Optionally the activating piston or retainer ring is
20 adapted to receive a retrieval tool such as a spear or
21 overshot.

22
23 Preferably the activating piston has an external split
24 ring mounted around the outside diameter.

25
26 Preferably the split ring can communicate with a groove
27 in the body of the reamer shoe, wherein the activating
28 piston is prevented from moving when the split ring is in
29 communication with said groove.

30
31 Preferably a plurality of ramps are located externally to
32 the activating piston.

33

1 Preferably the increase in hydrostatic pressure is
2 provided by an obstructing means within the internal bore
3 of the activating piston.
4
5 Most preferably said obstructing means is a deformable
6 ball or dart.
7
8 Preferably the reaming members are fully expanded when
9 the ball communicates with a seat formation in the
10 internal bore.
11
12 Preferably the ball is held inside the bore of the
13 activating piston by a retainer ring.
14
15 Preferably the retainer ring has a plurality of by-pass
16 ports which allow fluid and mud to pass through the
17 retainer ring.
18
19 Optionally the activating piston or retainer ring is
20 adapted to receive a retrieval tool such as a spear or
21 overshot.
22
23 Preferably the activating piston has an external split
24 ring mounted around the outside diameter.
25
26 Preferably the split ring can communicate with a groove
27 in the body of the reamer shoe, wherein the activating
28 piston is prevented from moving when the split ring is in
29 communication with said groove.
30
31 Preferably a plurality of ramps are located externally to
32 the activating piston.
33

1 Preferably the activating piston ramp segments, split
2 ring, ball, retainer ring and float valve are drillable.

3

4 In a second embodiment concept of the present invention,
5 the reaming members move from the first closed position
6 to the second expanded position by virtue of a
7 hydrodynamic pressure drop between the interior and
8 exterior of the reamer shoe.

9

10 Most preferably said hydrodynamic pressure drop is
11 created by one or more nozzles which may be attached to
12 the lowermost end of the reamer shoe.

13

14 Preferably the reaming members are held in the first
15 closed position by a plurality of leaf springs.

16

17 Preferably in the second expanded position the reaming
18 members are locked in position by a first and second
19 retaining block at either end.

20

21 Optionally the reamer shoe may contain a rupture means
22 such as a burst disc, wherein upon rupturing, the rupture
23 means permits the flow area of fluid from the interior of
24 the reamer shoe to the exterior to be increased for ease
25 of passage of cement, when cementing the casing, after
26 reaming to bottom.

27

28 Optionally the expandable reamer shoe may have a
29 cementing float valve fitted in the nose or the bore of
30 the body.

31

1 According to a second aspect of the present invention
2 there is provided a method of inserting expandable casing
3 into a borehole, comprising the steps of;

- 4 a) running a first section of expandable casing into a
5 pre-drilled borehole, expanding and then cementing
6 (if required) the expandable casing in place,
- 7 b) underreaming under the in-place casing using a
8 standard underreamer and pilot bit or an expandable
9 bit or bi-centre bit,
- 10 c) running a second length of expandable casing through
11 the in-place casing with an expandable reamer shoe
12 to ream down by rotation and/or reciprocation to
13 guarantee the hole is at the expected size
- 14 d) After reaming down, if needed, the expandable casing
15 can be expanded and then cemented (if required) to
16 create a slimhole or even a mono-bore well. The
17 expandable reamer shoe, as well as having expandable
18 blades, can also be designed to have its body
19 expanded in the same manner as the casing above it.

20

21 The method may further comprise the step of running a
22 subsequent section of casing through the in-place section
23 of expandable casing after drilling through the apparatus
24 of the first aspect to create a new hole or even to use a
25 casing drill shoe to drill out the nose of the expandable
26 reamer shoe for drilling and casing simultaneously.

27

28 In order to provide a better understanding of the
29 invention, an example first embodiment of the invention
30 will now be illustrated with reference to the following
31 Figures in which;

32

1 Figure 1 illustrates a cross sectional view of an
2 expandable reamer shoe in accordance with the present
3 invention,
4 Figure 2 illustrates an external view of an expandable
5 reamer shoe,
6 Figure 3 and 4 illustrate embodiments of the grooves
7 which co-operate with the split ring of the activating
8 piston, in an alternative cross sectional view expandable
9 reamer shoe,
10 Figure 5 illustrates the nose of an expandable reamer
11 shoe with a float valve included,
12 Figures 6 and 7 illustrate alternative retainer rings for
13 use with of an expandable reamer shoe,
14 Figure 8 is a cross sectional view of an alternative
15 second embodiment of an expandable reamer shoe,
16 Figure 9 and 10 illustrate the nose of the expandable
17 reamer shoe of Figure 8 with a float valve option, and;
18 Figures 11 and 12 illustrate an alternative cross
19 sectional view of the expandable reamer shoe of Figure 8.

20
21 Referring firstly to Figure 1, an expandable reamer shoe
22 which can drift and ream a drilled section of well bore
23 is generally depicted at 1 and is comprised of a
24 cylindrical body (2) with an eccentric nose with ledge
25 riding capability (3). The body (2) contains an
26 activating piston (4) which is moveable and which defines
27 an internal bore (5). The activating piston (4) has a
28 split ring (6) which is fitted onto the outside diameter
29 of the piston (4). The body (2) is made from steel and
30 has hard facing reaming members (6) which can be seen in
31 Figure 2 applied to the leading end for reaming the inner
32 most section of the drilled hole.

33

1 Upon assembly of the tool (1), the activating piston (4)
2 with the split ring (6) mounted thereon will be inserted
3 into the bore (5) of the body (2). Simple service
4 tooling is used to install the split ring (6) into the
5 bore (5) of the body (2). The piston (4) would be slid
6 down to the position shown on the lower side of the
7 centre line of Figure 1. A plurality of ramp segments
8 (7) would then be welded onto the outside of the piston
9 (4) through slots (8) in the wall of the body (2). The
10 slots (8) can be seen in more detail on the external view
11 of the reamer shoe (1) seen on Figure 2.

12

13 It can be seen from Figures 3 and 4 that the piston (4)
14 has six slots for the location of six ramp sections (7)
15 each of which corresponds with one of six external blades
16 (10). When the tool (1) is to be used as a reamer, the
17 blades (10) have hard facing pre-applied, for example,
18 hard or super hard metal or diamond. However when the
19 tool (2) is to be used solely as a drift, the blades (10)
20 will not need to have cutting grade hard facing. The
21 piston (4), split ring (6) and ramp segments (7) are all
22 made from a drillable material such as aluminium alloy.
23 The blades (10) and body (2) are made from a material of
24 medium hardness, such as alloy steel.

25

26 A deformable ball or dart (11) is then be dropped into
27 the bore (5) of the piston (4). The ball or dart (11),
28 which would typically be a rubber/plastic or
29 rubber/plastic coated ball can be seen on the lower side
30 of the centre line on Figure 1. A retainer ring (12) is
31 then screwed into place, the retainer ring (12) also
32 being made from a drillable material, such as aluminium
33 alloy. The retainer ring (12) has holes (13) which allow

1 fluid and mud to pass through the retainer ring (12) when
2 tripping the shoe (1) to the bottom of the well bore.
3 The eccentric nose (3) of the tool (1) may have hard
4 facing (6) applied on the outside and may also have a
5 float valve (14), as seen in Figure 4. The eccentric
6 nose (3) also has a bore which is large enough to
7 accommodate the ball (11) and is typically off-centre to
8 ensure that any subsequent drill bit (not shown) to be
9 passed through the tool (1) can drill through the ball.
10 This prevents the ball (11) from acting as a bearing upon
11 which the drill bit will spin on.

12
13 The assembly (1) can then be fitted onto the end of an
14 expandable casing (not shown) and run into a pre-drilled
15 well bore to the end of the section of well bore which
16 has already been drilled and cased. At the end of the
17 existing casing string, the tool (1) is activated just
18 after the new casing enters the new drilled hole section,
19 ie with the tool (1) in the rat hole below the existing
20 casing. This is achieved by applying power to mud pumps
21 (not shown), attached at the surface and to the top of
22 the pipe used for running the expandable casing. The
23 flow of mud in the first few seconds seats the ball (11)
24 into the piston (4), if it is not already in this
25 location. By applying static pressure thereafter, the
26 ball (11) will seal off the piston bore (5) and pressure
27 will be applied across the full area of the external seal
28 on the piston (4). Thus the piston (4) is encouraged to
29 move down the bore (5) of the body (2) of the tool and in
30 doing so deforms the plurality of blades (10) outwards,
31 by virtue of each of the blades (10) communicating with
32 its corresponding ramp segment (7). When the piston (4)
33 is moved down the bore (5) to the body (2), the ball (11)

1 will rest in position in a seat (18) as shown on the
2 upper side of the centre line in Figure 1. When the ball
3 (11) rests on the seat (18) in the position seen on the
4 upper side of the centre line in Figure 1, the piston (4)
5 is stationary and the blades (10) are expanded to gauge
6 size. In this position, the split ring (6) fits into a
7 corresponding groove (15), which prevents the piston (4)
8 from moving. The retainer ring (12) has seals (16) which
9 are external to the retainer ring (12). The retainer
10 ring (12) has two seals which fit into grooves (not
11 shown) on the external surface of the retainer ring (12).
12 When the seals (16) on the outside of the retainer ring
13 (12) travel past corresponding holes or ports (17) in the
14 body (2), there is a pressure drop at the surface which
15 indicates that the blades (14) are at their gauge size.

16

17 By continuing to pump dynamically flowing fluid through
18 the body (2) via the holes (17) to the outside, a dynamic
19 pressure drop will be created. This will normally be
20 lower than the static head which is required to push the
21 piston (4) to this position. However on increasing the
22 pump flow rate, the dynamic pressure head will be
23 increased to a level above the static pressure head which
24 is required to move the piston (4). As a consequence and
25 at a pre-determined calculated level, the ball (11) will
26 be pushed through the bore and the seat (18) of the
27 piston (4) upon which the ball sits and into a seat in
28 the eccentric nose (3). Mud can then flow through the
29 nose (3). Rotation of the string can then take place and
30 reaming to the bottom can commence.

31

32 Figure 5 illustrates a float valve (14) which can be
33 incorporated into the nose (3) of the tool (1). The

1 float valve (14) allows mud and cement to pass through
2 the nose (3) through the nozzles (19) in the nose (3) of
3 the reamer shoe (1) to the bottom of the well, so that it
4 can be displaced between the exterior surface of the
5 casing and the interior surface of the well bore, to
6 allow the casing to be cemented in place. However, the
7 float valve (14) also ensures that cement cannot flow
8 back into the reamer shoe through the nose although there
9 would be some leakage through the pressure relief holes
10 in the body adjacent to the retainer ring but the
11 diametrical gap between the retainer ring and the body
12 would be very small.

13

14 When reaming is completed, the nose (3), piston (4),
15 split ring (6), ball (11) and retainer ring (12) and
16 inside portion of the ramp segments can be drilled out
17 with the drill bit (not shown), with a gauge diameter
18 slightly smaller than the bore (5) of the body (2). The
19 design of the ramp segments located in the wall of the
20 body and welded to the piston prevents the piston and
21 retainer ring spinning when being drilled out. The body
22 (2) could also be expanded after drill out, by pushing a
23 pig or plug from above the reamer shoe (1). Note that a
24 seat for a hydraulic expansion seal dart could also be
25 located in the reamer shoe including at the entry to the
26 nose designed in this case so that the ball would still
27 pass by or through it, with the ball seat in the guide
28 end of the nose.

29

30 Figure 4 illustrates one embodiment of the invention,
31 which allows the blades (10) to be retracted after use,
32 wherein each of the blades (10) is adapted to correspond
33 with a ramp section (7) by a dovetail groove (20). The

1 retainer ring (12) is provided with a profiled end which
2 accommodates a retriever pulling tool (not shown), such
3 as an overshot or spear. The retriever pulling tool can
4 be used to pull the piston (4) back into its original
5 position, hence pulling the blades (10) back into the
6 body (2). Figure 5 illustrates a retainer ring (12)
7 which is adapted to suit a spear (21). Figure 6
8 illustrates a retainer ring (12) which is adapted with an
9 end to suit an overshot (22). It will be appreciated
10 that de-latching of the overshot or spear will also be
11 required in the event that it is desirable to pull back
12 the casing string for any reason after reaming has
13 commenced.

14

15 The tool (1) is designed to be welded while being
16 assembled and manufactured, so that the amount of
17 components within the internal bore (5) is minimised, and
18 accordingly there are less internal parts which need to
19 be drilled out for the next section of expandable casing.

20

21 The advantage of the above described embodiment lies in
22 the fact that it is possible to drill through the
23 expandable reamer shoe (1) after having reamed the
24 expandable casing to the bottom, and following expansion
25 and cementing of the expandable casing. However, it is
26 also recognised in this invention that the reamer shoe
27 (1) could be designed to act solely as a drift for the
28 drilled hole or as a drift in addition to being a reamer
29 shoe. Where the tool (1) is to be used as a drift, its
30 dimensions are slightly smaller than that of the outside
31 diameter of the drilled hole, and the tool will not
32 comprise cutting grade hard facing. It is also

1 recognised that the tool (1) could also be used with
2 standard casing as opposed to expandable casing.

3

4 An alternative second embodiment of the reamer shoe is
5 shown in Figure 8, generally depicted at 23. The shoe
6 (23) is made entirely from steel and is millable as
7 opposed to drillable. The shoe (23) can also be
8 retrieved back to the surface if required. The reamer
9 shoe (23) can also be used with a final casing string,
10 for example in a section which does not require drill-
11 out.

12

13 The body (24) of the tool has three pockets each of which
14 holds a blade (25) with hard metal or super hard metal or
15 diamond, or other cutting grade material on the external
16 surface, as shown in Figures 11 and 12. It will be
17 appreciated that the cutting grade material will not be
18 included on the blade (25) if the reamer shoe (23) is to
19 be used as a drift only. The blades (25) are activated
20 by the flow of fluid through the ports or nozzles (26) in
21 the eccentric nose (27) of the tool (23) which creates a
22 dynamic pressure drop between the inside and outside of
23 the tool (23). This forces the blades (25) out against
24 leaf springs (28) which are mounted in additional pockets
25 along the length of the sides of the blades (25). Each
26 blade (25) has a series of blade pistons (29) which are
27 screwed into the base of the pockets of the body (24).
28 The blades (25) are driven out to the gauge diameter by
29 the dynamic pressure drop, against stop blocks (30) which
30 are located at either end of each of the blades (25).
31 The blades (25) are locked in place by the spring
32 activated blocks (30), and reaming then commences to the
33 bottom of the bore. A means to indicate that the blades

1 (25) are at the gauge size could be achieved by adding a
2 pressure relief valve (not shown). The leaf springs (28)
3 hold the blades (25) into the body (24) when the tool
4 (23) is tripped into the hole. Figure 9 illustrates a
5 cross section of the body (24) when the blades (25) are
6 closed. Figure 10 illustrates the same cross section of
7 the body (24) when the blades are expanded.

8
9 If the tool (23) is to be used on the final string of
10 casing, the tool can be left in-situ without being
11 drilled out. In addition, a float valve (31) can be
12 fitted to the eccentric nose (27) of the tool (23) to aid
13 cementing. Figure 10 illustrates the float valve (31)
14 wherein the valve is closed thereby obturating the entry
15 of fluid such as cement or mud from the body (24) of the
16 tool (23) into the nose (27). Figure 12 shows the float
17 valve (31) when open, which allows fluid to flow into the
18 nose (27) when reaming. If a float valve (31) is not
19 fitted to the nose (27), the nose (27) can be made
20 integrally with the body (24).

21
22 The casing can be retrieved at any time while reaming, by
23 pulling the casing string uphole until the blades (25)
24 bear against the end of the shoe of the last casing
25 string, and by applying tension to the string from the
26 surface. This will push the blades (25) into the body
27 (24) by shearing the spring activated blocks (30). A
28 bursting disk (32) may also be incorporated into the body
29 (24) of the tool to increase the flow area through the
30 tool for cementing. It is envisaged that a bursting disk
31 (32) will be incorporated into the shoe (23) if the
32 nozzles (26) of the nose (27) are small. Incorporation
33 of the bursting disk will ensure that a reasonably high

1 cross sectional flow area is available for cement to pass
2 through. When using a burst disk it is likely that the
3 nose will not incorporate a float valve as the cement
4 could flow back in through the hole after the disc was
5 burst. In this case the float valve would be fitted
6 above the burst disc location.

7
8 An advantage of the present invention is that the reamer
9 shoe can be expanded prior to the passage of expandable
10 casing which will ensure that the casing can expand fully
11 to the desired gauge size. A further advantage is that
12 the reamer shoe may be drilled through by a subsequent
13 drill bit or casing drill shoe with the first embodiment
14 design. This allows further sections of a well-bore to
15 be drilled below the region which has been lined by the
16 expandable casing, without any damage to the drill bit.
17 The expandable reamer shoe can also be advanced into the
18 borehole by reciprocation and/or rotation.

19
20 Further modifications and improvements may be
21 incorporated without departing from the scope of the
22 invention herein intended.

1 **CLAIMS**

2

3 1. An expandable reamer shoe for mounting on a casing
4 string, the shoe having a body upon which are
5 arranged a plurality of reaming members wherein said
6 reamer shoe is substantially constructed from a
7 relatively soft drillable material, wherein the
8 plurality of reaming members are moveable between a
9 first and second position, and wherein the reaming
10 members are closed in a first position and expanded
11 in a second position.

12

13 2. An expandable reamer shoe as claimed in Claim 1,
14 wherein the plurality of reaming members are in the
15 form of blades.

16

17 3. An expandable reamer shoe as claimed in Claim 2,
18 wherein each of the blades has a hard facing applied
19 to an outer surface.

20

21 4. An expandable reamer shoe as claimed in any
22 preceding Claim, wherein the reaming members move
23 from the first closed position to the second
24 expanded position by virtue of movement of an
25 activating piston.

26

27 5. An expandable reamer shoe as claimed in Claim 4,
28 wherein said activating piston defines an internal
29 bore.

30

31 6. An expandable reamer shoe as claimed in Claim 4 or
32 Claim 5, wherein movement of the activating piston
33 is provided by an increase in hydrostatic pressure.

- 1
- 2 7. An expandable reamer shoe as claimed in Claim 6,
3 wherein the increase in hydrostatic pressure is
4 provided by an obstructing means within the internal
5 bore of the activating piston.
6
- 7 8. An expandable reamer shoe as claimed in Claim 7,
8 wherein said obstructing means is a deformable ball
9 or dart.
10
- 11 9. An expandable reamer shoe as claimed in Claim 8,
12 wherein the reaming members are fully expanded when
13 the ball/dart communicates with a seat formation in
14 the internal bore.
15
- 16 10. An expandable reamer shoe as claimed in Claim 8 or
17 Claim 9, wherein the ball/dart is held inside the
18 bore of the activating piston by a retainer ring.
19
- 20 11. An expandable reamer shoe as claimed in Claim 10,
21 wherein the retainer ring has a plurality of by-pass
22 ports which allow fluid and mud to pass through the
23 retainer ring.
24
- 25 12. An expandable reamer shoe as claimed in any one of
26 Claim 4 to Claim 11, wherein the activating piston
27 is adapted to receive a retrieval tool such as a
28 spear or overshot.
29
- 30 13. An expandable reamer shoe as claimed in Claim 10 or
31 Claim 11, wherein the retainer ring is adapted to
32 receive a retrieval tool, such as a spear or
33 overshot.

- 1
2 14. An expandable reamer shoe as claimed in any of Claim
3 4 to Claim 13, wherein the activating piston has an
4 external split ring mounted around an outside
5 diameter.
6
- 7 15. An expandable reamer shoe as claimed in Claim 14,
8 wherein the split ring can communicate with a groove
9 in the body of the reamer shoe, wherein the
10 activating piston is prevented from moving when the
11 split ring is in communication with said groove.
12
- 13 16. An expandable reamer shoe as claimed in any one of
14 Claim 4 to Claim 15, wherein a plurality of ramps
15 are located externally to the activating piston.
16
- 17 17. An expandable reamer shoe as claimed in any one of
18 Claim 1 to Claim 3, wherein the reaming members move
19 from the first closed position to the second
20 expanded position by virtue of a hydrodynamic
21 pressure drop between an interior and exterior of
22 the reamer shoe.
23
- 24 18. An expandable reamer shoe as claimed in Claim 16,
25 wherein said hydrodynamic pressure drop is created
26 by one or more nozzles attached to a lowermost end
27 of the reamer shoe.
28
- 29 19. An expandable reamer shoe as claimed in any
30 preceding Claim, wherein the reaming members are
31 held in the first closed position by a plurality of
32 leaf springs.
33

1 20. An expandable reamer shoe as claimed in any
2 preceding Claim, wherein in the second expanded
3 position the reaming members are locked in position
4 by a first and second retaining block at each end of
5 the reaming member(s).
6

7 21. An expandable reamer shoe as claimed in any
8 preceding Claim, wherein the reamer shoe includes a
9 rupture means such as a burst disc which permits
10 increased fluid flow from an interior of the reamer
11 shoe to the exterior of the reamer shoe.
12

13 22. An expandable reamer shoe as claimed in any
14 preceding Claim, wherein the expandable reamer shoe
15 includes a cementing float valve.
16

17 23. A method of inserting expandable casing into a
18 borehole, comprising the steps of:
19

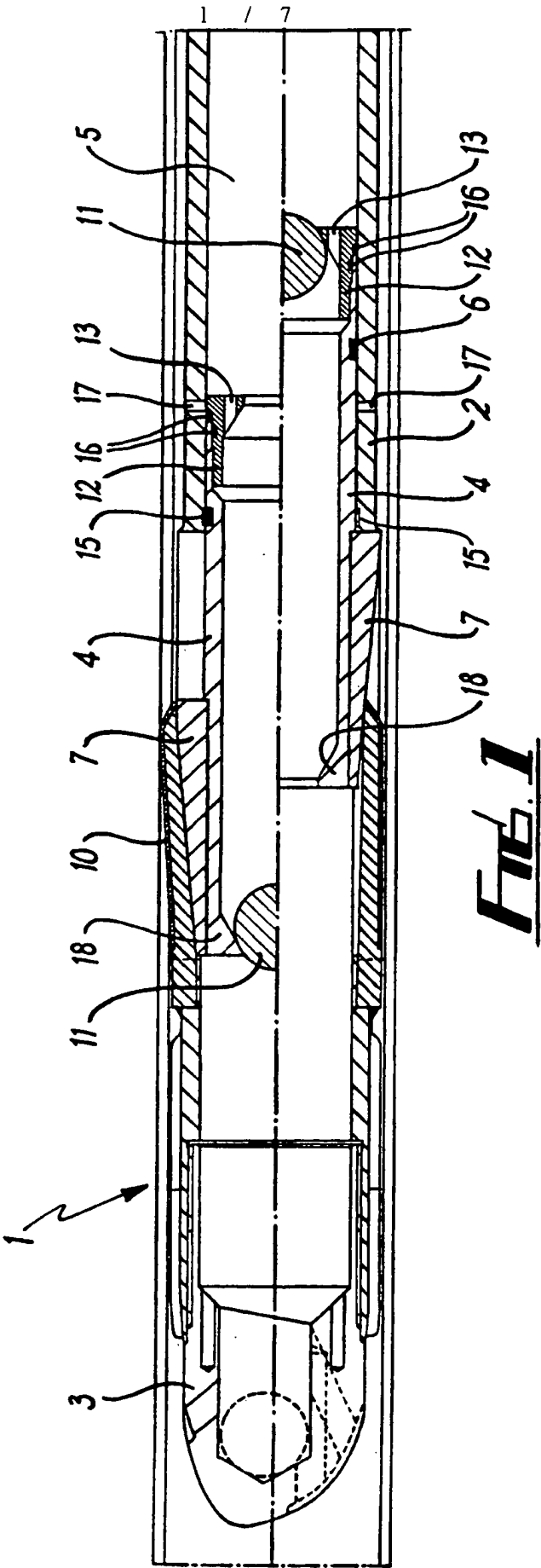
20 (a) running a first section of expandable casing
21 into a pre-drilled borehole;
22

23 (b) expanding the first section of expandable
24 casing in place;
25

26 (c) underreaming under the in-place first section
27 of expanded casing using a standard underreamer
28 and bit;
29

30 (d) running a second section of expandable casing
31 through the first section of expandable casing
32 with an expandable reamer shoe; and
33

- 1 (e) reaming down the borehole by rotation and/or
2 reciprocation of the expandable reamer shoe to
3 an expected size.
4
- 5 24. A method as claimed in Claim 23, wherein the method
6 includes the step of drifting the expandable reamer
7 shoe.
8
- 9 25. A method as claimed in Claim 23 or Claim 24, wherein
10 the method includes the step of expanding the second
11 section of expandable casing into the reamed
12 borehole.
13
- 14 26. A method as claimed in any one of Claims 23 to 25,
15 wherein the method includes the step of cementing
16 the expandable casing.
17
- 18 27. A method as claimed in any one of Claims 23 to 26,
19 wherein the expandable reamer shoe is as claimed in
20 any one of Claims 1 to 22.
21
- 22 28. A method as claimed in any one of Claims 23 to 26,
23 wherein the method includes the step of expanding
24 the body of the expandable reamer shoe.
25
- 26 29. A method as claimed any one of Claims 23 to 27,
27 wherein the method includes the step of drilling
28 through the expandable reamer shoe prior to running
29 a subsequent section of expandable casing through an
30 in-place section of expandable casing.
31



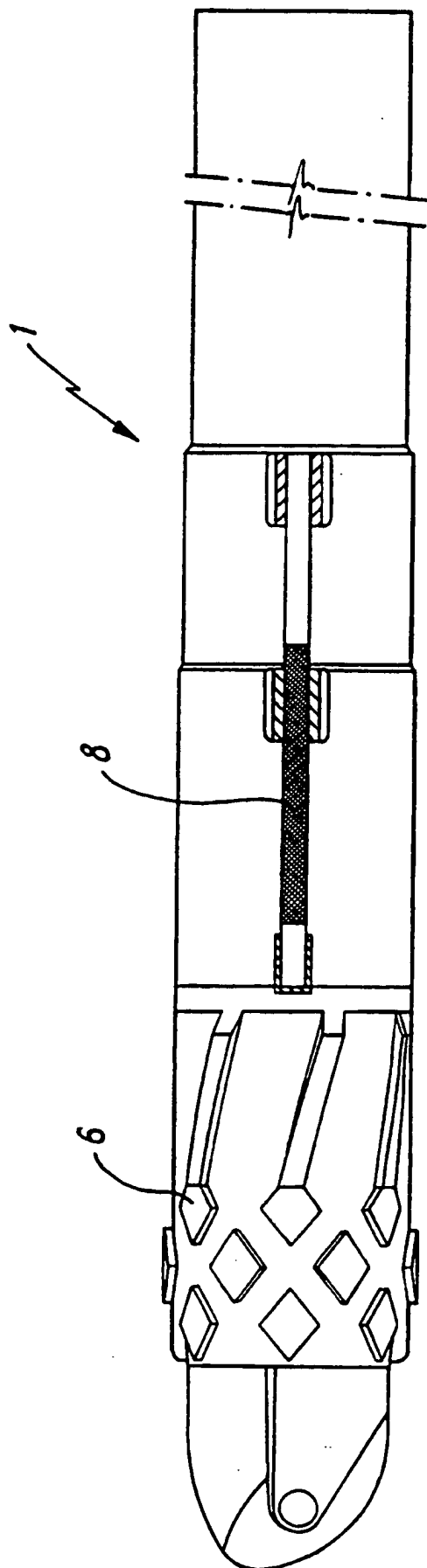


Fig. 2

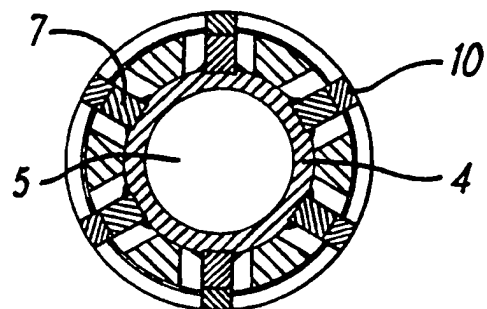


FIG. 3

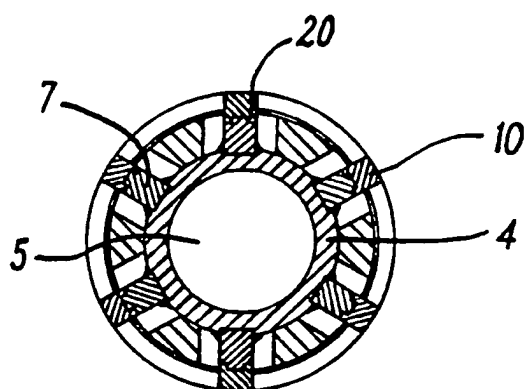


FIG. 4

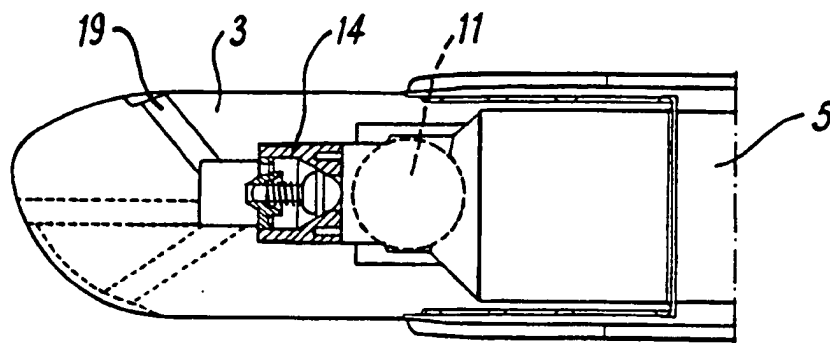


Fig. 5

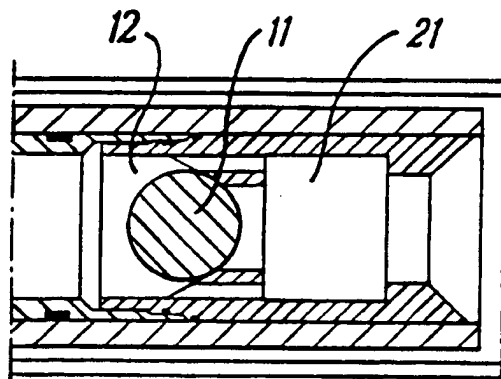


Fig. 6

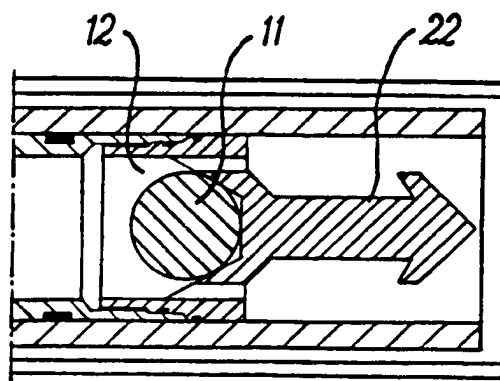
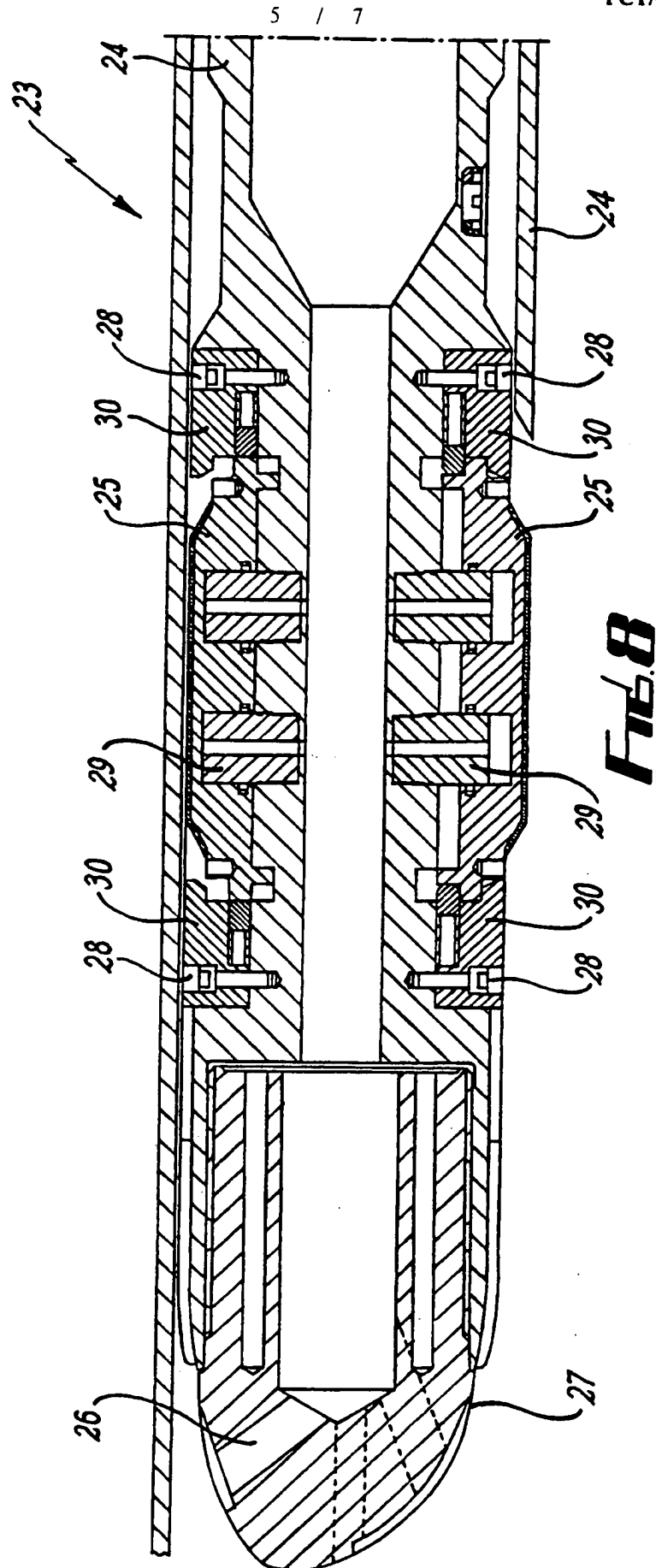


Fig. 7



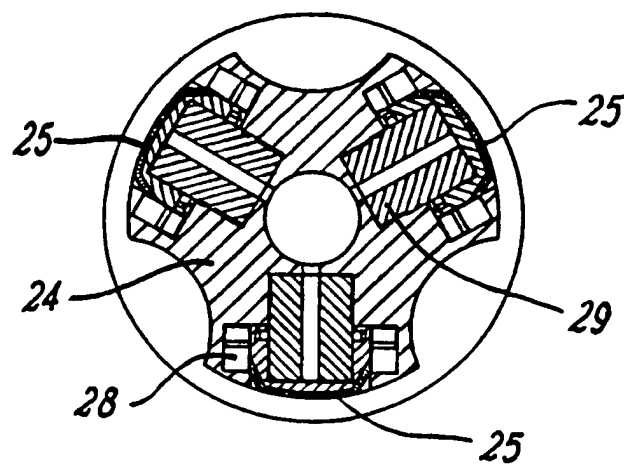


Fig. 9

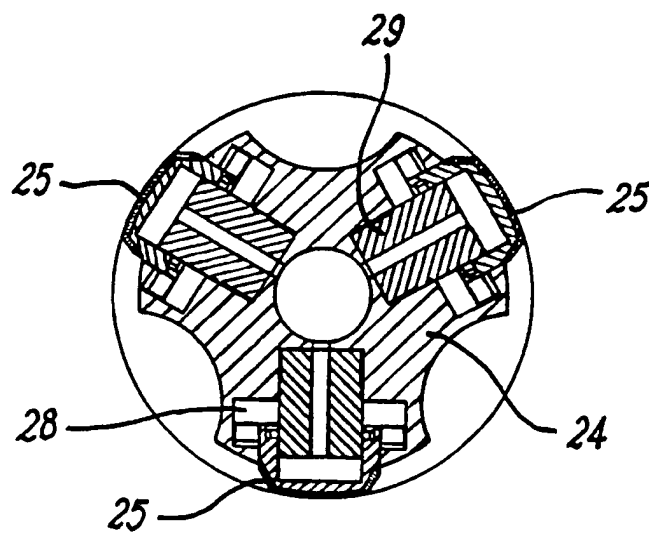


Fig. 10

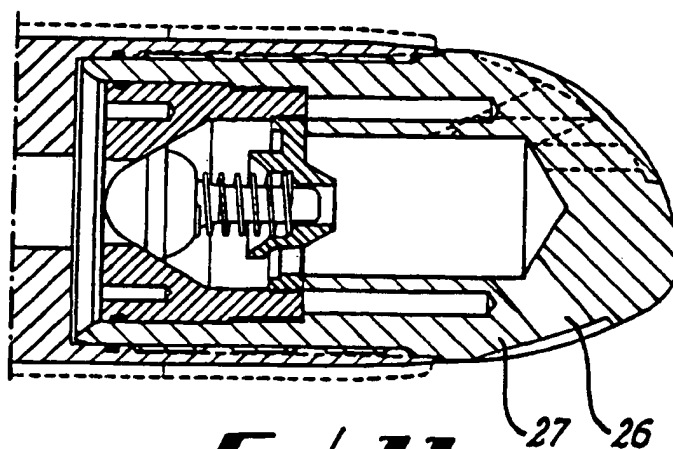


FIG. 11

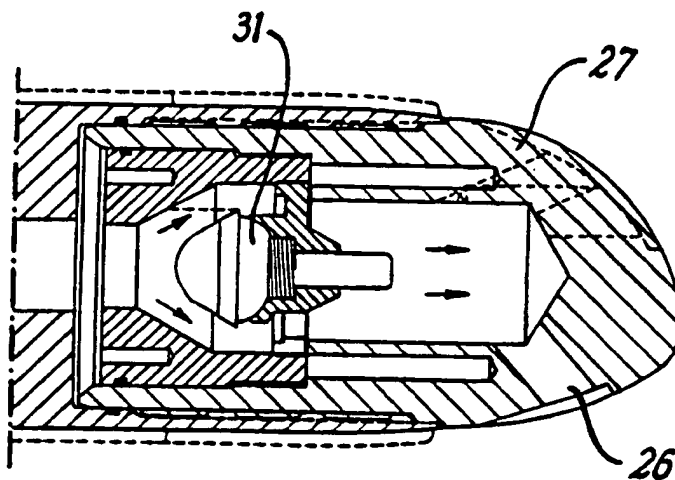


FIG. 12

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/01512

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B7/20 E21B17/14 E21B43/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 552 510 A (BROWN CICERO C) 5 January 1971 (1971-01-05) column 6, line 35 - line 48; figures 1,2	1-8, 16-18, 20,23, 25-27
Y	WO 99 64713 A (WARDLEY MICHAEL ;BBL DOWNHOLE TOOLS LTD (GB)) 16 December 1999 (1999-12-16) page 8, line 11 -page 9, line 8	1-8, 16-18, 20,27
Y	US 5 361 859 A (TIBBITTS GORDON A) 8 November 1994 (1994-11-08) column 5, line 35 - line 46; figure 1 -/--	16

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

11 July 2001

Date of mailing of the international search report

19/07/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Garrido Garcia, M

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 01/01512

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	FR 2 741 907 A (DRILLFLEX) 6 June 1997 (1997-06-06) page 4, line 3 - line 33 page 6, line 3 - line 12 ---	23,25-27
A	WO 96 28635 A (BRIT BIT LIMITED ;STRONG PHILLIP (GB); WARDLEY MICHAEL (GB)) 19 September 1996 (1996-09-19) page 9, line 12 - line 22 ---	1-29
A	GB 2 333 542 A (DOWNHOLE PRODUCTS PLC) 28 July 1999 (1999-07-28) abstract -----	1-29

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 01/01512

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 3552510	A	05-01-1971	NONE	
WO 9964713	A	16-12-1999	AU 4279499 A EP 1086292 A NO 20006303 A	30-12-1999 28-03-2001 15-12-2000
US 5361859	A	08-11-1994	BE 1010105 A GB 2275067 A,B GB 2301386 A,B US 5560440 A	02-12-1997 17-08-1994 04-12-1996 01-10-1996
FR 2741907	A	06-06-1997	NONE	
WO 9628635	A	19-09-1996	AT 174403 T AU 713736 B AU 4950396 A CA 2214749 A DE 69601129 D EP 0815342 A NO 974181 A US 6062326 A	15-12-1998 09-12-1999 02-10-1996 19-09-1996 21-01-1999 07-01-1998 05-11-1997 16-05-2000
GB 2333542	A	28-07-1999	AU 2172699 A EP 0995008 A WO 9937881 A GB 2339227 A	09-08-1999 26-04-2000 29-07-1999 19-01-2000